Environmental Toolbox

Technical Module

Solid Waste Management

Objectives

- Understand the importance of solid waste (SW) management
- Be familiar with common SW management procedures
- Assemble data to make an informed choice for a SW management system
- Know the key steps in waste planning
- Develop knowledge about the risks, regulations and preventive measures in the handling of waste
- Prepare for the most common obstacles of waste ha

Know your responsibilities regarding waste management!

Definitions

- ***Solid Waste (SW):*** Any substance, material or object which the holder discards, intends to discard, or is required to discard
- ***Hazardous Waste (HW):*** Any material considered discarded, abandoned, or unusable that may pose a real hazard to human health or the environment
- ***Recycling:*** The reprocessing in a production process of the waste materials for the original purpose or for other purposes, including organic recycling but excluding energy recovery
- ***Reuse:*** The use of an item again for the same or different function
- ***Waste management (WM):*** Collection, transport, recovery and disposal of waste, including the supervision of such operations and after-care of disposal sites

Significance and Benefits

Good solid waste management can:

- Enhance mission accomplishment by improving base camp quality of life by minimizing:
  - Exposure to waste-related health issues
  - Unnecessary environmental damage
- Contribute to force protection
- Promote good relations with the Host Nation
- Free up resources for the mission (camp space, transportation, funds, etc.)

Waste management is usually one of most significant environmental aspects, but also one that can be greatly reduced

Negative Consequences

- Poor waste and material management can cause:
  - Direct health problems through vermin, air pollution and contamination of drinking water
  - Large transportation and labor requirements
  - Increased waste management at closure
  - Potential security concerns
  - Increased costs

Elements of a Waste Hierarchy

Most Favored Option

Waste Avoidance

Reuse

Recycle

Treatment

Waste Disposal

Least Favored Option

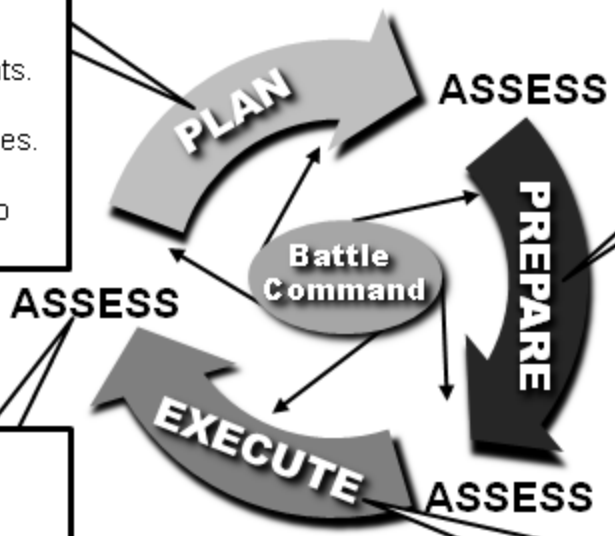
EO Responsibilities

- Develop the Solid Waste Management Plan, using the 6-step Waste Management Process
- Train personnel on SW management requirements
- Coordinate with safety and health officers to ensure safe procedures and protocols
- Monitor performance of SW management systems
  - Segregation, storage, transportation, contractor activity as applicable, etc.
- Follow up and report
- Maintain documentation

WM Process Overview

- Apply the 6-step process for developing a waste management plan:
  - Analyze the situation.
  - Develop preliminary waste requirements.
  - Categorize waste requirements.
  - Evaluate waste management capabilities.
  - Generate solutions.
  - Integrate waste management tasks into plans and orders.

- Facilitate subordinates' planning.
- Refine the waste management plan based on new information and changes in the situation.
- Monitor the progress of ongoing waste management tasks.



- Manage the execution of the waste management plan:
  - Construction management.
  - Contract compliance.
  - Quality assurance/quality control.
- Monitor the situation:
  - Changes in the duration of the mission.
  - Base camp establishment, realignment, and closure.

- Monitor the performance of waste management systems.
- Assess effectiveness and appropriateness.

Waste Management Plan

In a waste management plan, all waste management aspects must be dealt with. The waste management plan must comprise at least the following aspects:

a) A list and map depicting waste generation activities/locations and waste collection points for each differing waste stream (residual and recyclable wastes), including relevant information (e.g., points of contact)
b) A list of the types of waste, including estimated quantities and disposal capacities
c) Necessary safety and health information applicable to specific wastes generated
d) A list of local authorities, local laws and regulations and approved local contractors
e) Separation of waste by different categories/into different fractions
f) Procedural instructions for safe handling and disposal
g) Assignment of responsibilities within the military sector

Six-Step SW management Process

- Initial considerations
- Six-step development process
  1. **Analyze the situation,** e.g., security level, location, duration, size, geology and economy
  2. **Develop preliminary waste estimates for:** kitchen, workshop, petroleum oils and lubricants (POL) handling, incoming goods, number of personnel, etc.
  3. **Categorize waste requirements (time-scale):** appropriate methods are based on mission duration
  4. **Evaluate SW management capabilities:** HN and/or contractors' abilities, equipment options, etc.
  5. **Generate solutions suitable for the mission** solutions must meet specific requirements and be in accordance with the waste hierarchy
  6. **Integrate waste management tasks into plans and orders**
- Continue to monitor

Initial Considerations

- Start planning early
- Fulfill current requirements and anticipate future needs
- Site location
  - SW disposal should be downwind of inhabited areas
  - Landfills should be sited as far as practicable from airfields to avoid bird strike hazards
  - Allow easy access for collection vehicles
  - Avoid sensitive environmental areas

Analyze the Situation

- Goal: understand how, where, and how much SW will be generated by the unit
- Considerations
  - Mission
  - Local threat conditions
  - Terrain and weather
  - Troops and support available
  - Time
  - Civil considerations
  - Available infrastructure
  - Others

Develop Preliminary Waste Estimates

Component	Rate (%)
Generation Rate on the Move – 1.8 kg / person / day	
General refuse	37.5
Food waste	62.5
Total nonhazardous solid waste	100%
Generation Rates in Base Camps – 4.5 kg / person / day	
Plastic bottles	4
Other plastics	10
Aluminum	1
Cardboard	11
Paper	20
Food waste	12
Textiles	2
Glass	1
Scrap wood	22
Miscellaneous	17
Total solid waste	100%

Consider Duration of Mission

- Short (sustain operations for a minimum of 60 days)
- Medium (Approximately 60-180 days)
- Long (more than 180 days)
- Closing

Evaluate SW Management Capabilities

- Can your unit meet its waste requirement needs?
- Does your unit have adequate resources to include:
  - Manpower
  - Equipment
  - Materials
  - Funding
- Identify potential shortfalls
  - What are HN and/or contractor capabilities to address these shortfalls?

Generate Solutions

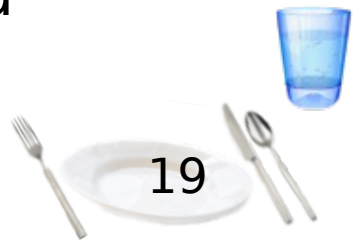
- Determine potential solutions that are:
  - Feasible
  - Suitable
  - Sustainable
- If contracting is required, ensure environmental considerations are included:
  - Performance work statement
  - Monitoring and evaluation plan
- Evaluate options and present at Environmental Management Board (EMB) for Commander's decision on the approved course of action (COA)

Integrate SW Management into Plans and Orders

- Finalize the plan that supports the approved COA
- Plan should contain the who, what and when for each step in the WM process:
  - Waste avoidance and minimization
  - Segregation/Collection
  - Transportation
  - Recycling/Reuse
  - Treatment
  - Disposal

Waste Avoidance and Minimization

- Order and use only what is needed
- Reuse materials when possible instead of discarding them
  - Create a location for reusing materials such as furniture, books, etc.
- In procurement processes, focus on ways to minimize waste and potential negative environmental impacts:
  - Avoid products with unnecessary packaging or packaging that is difficult to recycle or dispose
  - Replace disposable items with reusable ones when possible (e.g., plates, silverware, trays)
  - Avoid chemicals with negative health and environmental impacts
  - Choose easily recyclable materials
  - Use available technology to pre-process waste for recycling, treatment or disposal
- Educate base personnel on waste avoidance and minimization



Segregation/Collection

- Segregate SW at point of generation in clearly marke containers to:
  - Conserve resources
  - Reduce chance of mishaps
  - Minimize personnel exposure
  - Maximize recycling capability
- Determine frequency and number of collection points needed
- Educate base personnel on segregation requirements

Color coded containers simplify segregation

Transportation

- Use vehicles dedicated for trash removal, if possible
  - Bed should be covered to prevent trash blow off
  - Minimize routes through billeting
  - Perform dust abatement as necessary
- Ensure personnel are wearing appropriate personal protective equipment (PPE)

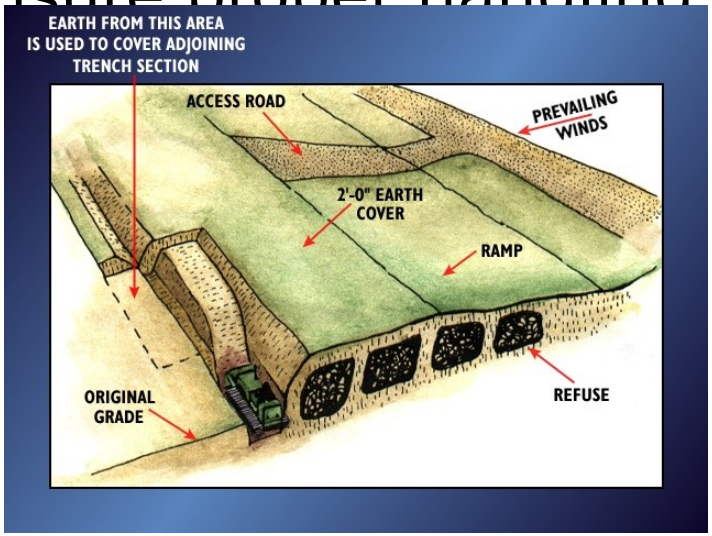
Recycling and Reuse

Treatment

- Treatment: A change in character or composition of waste, to reduce or eliminate potential hazard
  - Chemical – e.g., pH neutralization of waste sludge
  - Biological – e.g., composting
  - Mechanical – e.g., baling, shredding, compacting
- Treatment may be performed in conjunction with or as a disposal method in itself

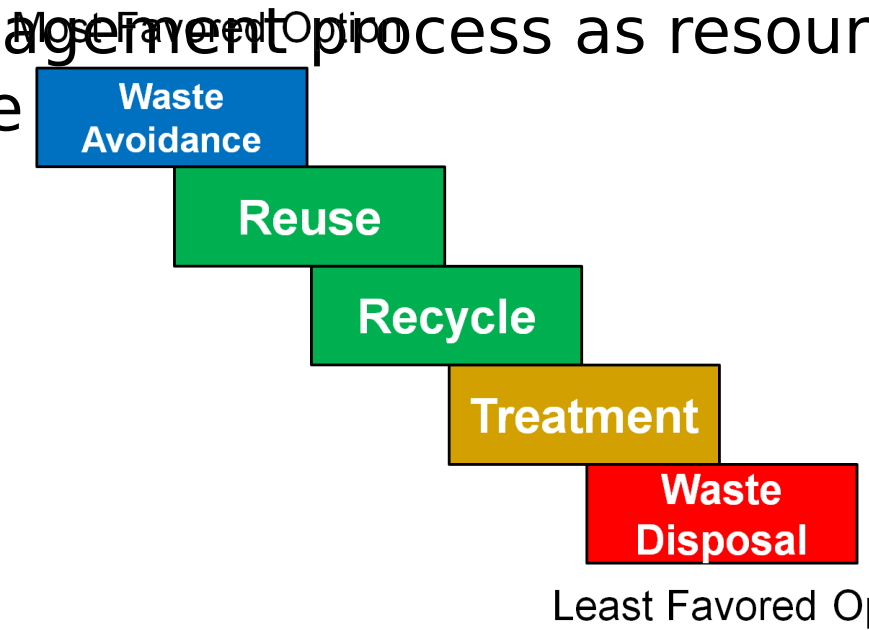
Disposal

- The least desirable SW management option is disposal
- Common disposal methods are technologies based on burying or burning
- If contractor support is required, perform quality assurance inspections to ensure proper handling and disposal of SW



Continue to Evaluate and Monitor the SW Management Program

- A successful SW management program is able to adapt to changing mission requirements
- Maintain tracking documentation to improve estimates on waste generation quantities for each waste stream
- Strive for continual improvement by upgrading SW management process as resources become available



Recycling and Recovery Options

Waste Oil Regeneration

- Advantages
  - Reduced transportation
  - Reduced logistics
  - Possible energy source
  - Saves resources
- Disadvantages
  - Oil quality not guaranteed for reuse
  - Spill risks
- Limitations
  - Amount of waste oil

Duration Suitability Index

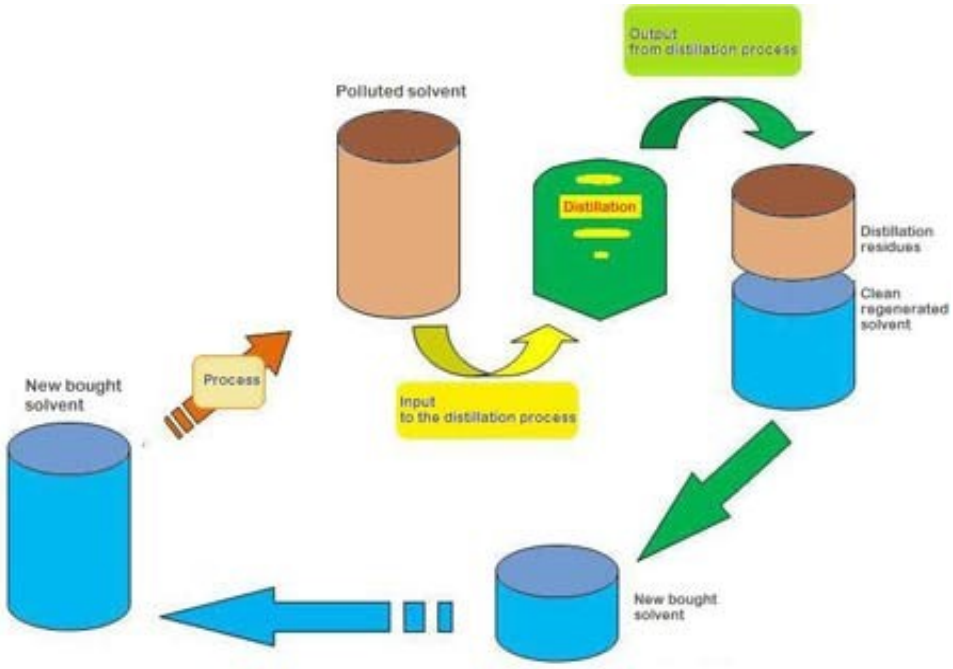
Short	Medium	Long

Solvent Regeneration

- Advantages
  - Reduced transportation
  - Reduced logistics
  - Saves resources
- Disadvantages
  - Quality not guaranteed for reuse
  - Spill risks
- Limitations
  - Amount of solvent

Duration Suitability Index

Short	Medium	Long



Antifreeze Regeneration

- Advantages
  - Reduced waste
  - Reduced transportation
  - Reduced logistics
  - Saves resources
- Disadvantages
  - Quality not guaranteed for reuse
  - Spill risks
- Limitations
  - Amount of antifreeze

Duration Suitability Index

Short	Medium	Long

Oil-Contaminated Soil Composting

- Advantages
  - Does not leave contaminated soil
  - Useable end product
  - Reduced logistics
- Disadvantages
  - Land requirement
  - Skilled personnel (education/equipment)
  - Time
- Limitations
  - Available material for composting (manure)

Duration Suitability Index

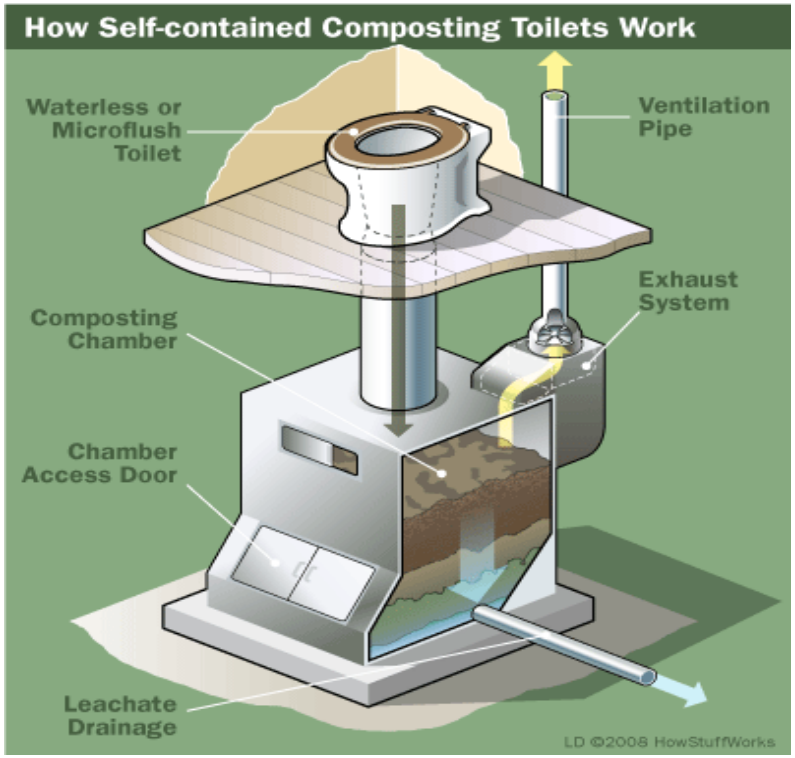
Short	Medium	Long

Latrine Compost

- Advantages
  - Minimizes waste
  - Reduced transportation
- Disadvantages
  - Handling latrine contents
  - Health risks
  - Time efforts
  - Space requirements
- Limitations
  - Space
  - Infrastructure
  - Appropriate only for small number of forces

Duration Suitability Index

Short	Medium	Long



Dehydration and Slime Removal of Kitchen and Food Wastes

- Advantages
  - Combustible end product
  - Reduces risk of smell and vermin
  - Hygienic
  - Reduces handling
  - Space efficient
- Disadvantages
  - Capital cost
- Limitations
  - Only for food/wet waste

Duration Suitability Index

Short	Medium	Long

Baling

- Advantages
  - Reduced transportation
  - Space efficient
- Disadvantages
  - Capital costs
  - Education of personnel
  - Maintenance
- Limitations
  - Contractors' ability to handle and receive baled material
  - Enough material to bale

Duration Suitability Index

Short	Medium	Long

Shredding

- Advantages
  - Reduced transportation
  - Space efficient
- Disadvantages
  - Capital costs
  - Education of personnel
  - Maintenance
- Limitations
  - Contractors' ability to handle and receive shredded material in a safe and proper way

Duration Suitability Index

Short	Medium	Long

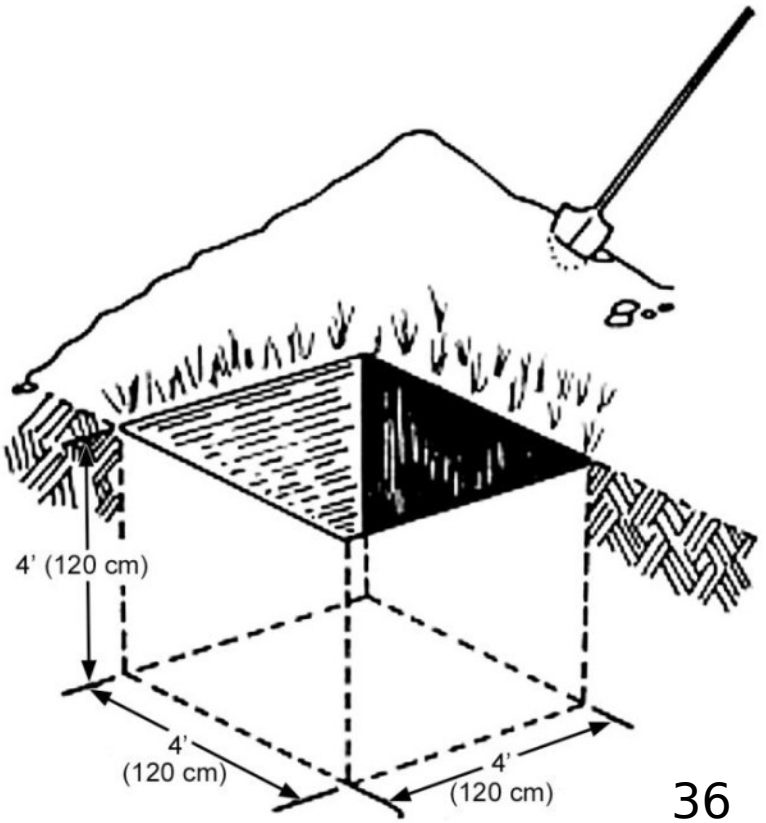
Disposal Options

Bury in Place: Simple Landfill

- Advantages
  - Low initial cost
  - Low air emissions
- Disadvantages
  - Labor intensive
  - Land requirement
- Limitations
  - Only viable for small forces, short duration
  - Non-hostile environment

Duration Suitability Index

Short	Medium	Long



Simple Landfill

General Design Considerations	A pit is dug and filled to not more than 1 foot from the top, then covered, compacted and mounded with 1 foot of earth. Bury in place should only be used when units are on the move or are stationary in a position for less than 1 week, or when established landfills are unavailable.
Limitations	Force Protection, land availability, base population, health concerns (vector-borne diseases)
Recordkeeping, Reporting	Location, contents of waste, dates of burial, pictures
Capital Costs	None
Operations & Maintenance (O&M) Requirements	For a larger simple landfill, earthmoving equipment and additional manpower will be necessary
Transfer/Closure Requirements	Place a rectangular sign on top of the site indicating the type of pit/trench, the date it was closed, and the unit designation if the situation allows. An 8-digit grid coordinate is recorded for each waste burial site and reported to higher headquarters.
References	• U.S. Army Engineer School and Regiment, *Commander's Handbook: Waste Management for Deployed Forces*, April 2010 • U.S. Army, *Environmental Considerations*, FM 3-34.5/MCRP 4-11B, February 2010 • U.S. Air Force, *Environmental Considerations for Overseas Contingency Operations*, Air Force Handbook 10-222, Vol. 4

Burn Pit

- Advantages
  - Low initial cost
  - Low operating cost
- Disadvantages
  - Air emissions
  - Human health effects
  - Labor intensive
- Limitations
  - Not authorized in many locations
  - Cannot handle all waste types
  - Needs to be sited far from personnel and airfields

Duration Suitability Index

Short	Medium	Long

Burn Pit

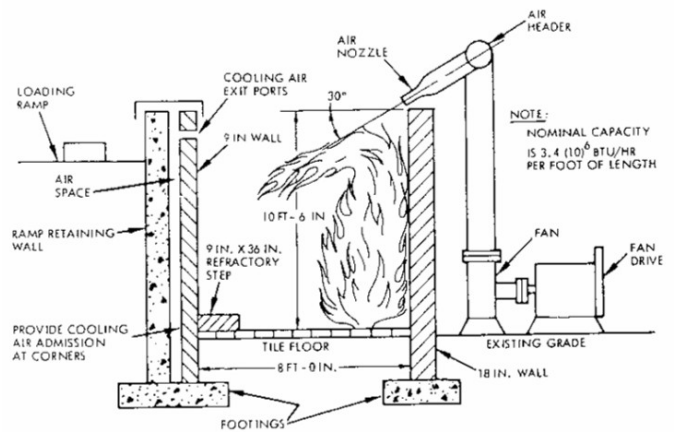
General Design Considerations	Locate downwind of inhabited areas Do not conduct burn operations during weather prohibitive conditions (e.g. during or after rain events, during inversions)
Limitations	Recommendation – burn pit usage is not to exceed one year after the establishment of a base camp. Cannot burn covered wastes (e.g., plastics, hazardous waste, medical waste, tires, treated wood)
Recordkeeping, Reporting	Location, contents of waste, dates of opening/closure, pictures, amount, air sampling
Capital Costs	Earthmoving equipment
O&M Requirements	Manpower
Transfer/Closure Requirements	Soil sampling, groundwater sampling (consideration) Bury any existing trash and ash, cap existing area Place a rectangular sign on top of the site indicating the type of burn operations, the date it was closed, and the unit designation if the situation allows. An 8-digit grid coordinate is recorded for each waste burial site and reported to higher headquarters
References	• U.S. Army Engineer School and Regiment, *Commander's Handbook: Waste Management for Deployed Forces*, April 2010 • U.S. Air Force Instruction, *Waste Management*, AFI 32-7042, 2010 • U.S. Army, *Environmental Considerations*, FM 3-34.5/MCRP 4-11B, Feb. 2010 • U.S. Air Force, *Environmental Considerations for Overseas Contingency Operations*, Air Force Handbook 10-222, Vol. 4 • U.S. Department of Defense Instruction (DODI) 4715.19, Use of Open-Air Burn Pits in Contingency Operations

Air Curtain and Mobile Incinerator

- Advantages
  - Effective
  - Smaller land requirement
  - Lower air emissions
  - Easier to set-up than larger incinerator
- Disadvantages
  - Higher capital cost
  - Skilled operators
  - Higher operations and maintenance (O&M) costs
- Limitations
  - Acquisition and delivery timeline
  - Suitable only for smaller force

Duration Suitability Index

Short	Medium	Long



Air Curtain and Mobile Incinerator

General Design Considerations	Locate downwind of inhabited areas Do not conduct burn operations during weather prohibitive conditions (e.g., during or after rain events, during inversions).
Limitations	Force Protection, land availability, base population, health concerns (vector-borne diseases) Cannot burn covered wastes (e.g., plastics, hazardous waste, medical waste, tires, treated wood)
Recordkeeping, Reporting	Location, contents of waste, dates of opening/closure, pictures, amount, air sampling
Capital Costs	Incinerator, earthmoving equipment
O&M Requirements	Manpower, ash removal and burial
Transfer/Closure Requirements	Soil sampling, groundwater sampling (consideration) Bury any ash residue. Sanitize and repack equipment for return to home station. Place a rectangular sign on top of the site indicating the incinerator operations, the date it was closed, and the unit designation if the situation allows. An 8-digit grid coordinate is recorded for each waste burial site and reported to higher headquarters.
References	•U.S. Army Engineer School and Regiment, *Commander's Handbook: Waste Management for Deployed Forces*, April 2010

Fixed Incineration

- Advantages
  - Effective
  - Smaller land requirement
  - Lower air emissions
- Disadvantages
  - Highest capital cost
  - Skilled operators
  - Highest O&M costs
- Limitations
  - Acquisition and delivery timeline

Duration Suitability Index

Short	Medium	Long

Fixed Incineration

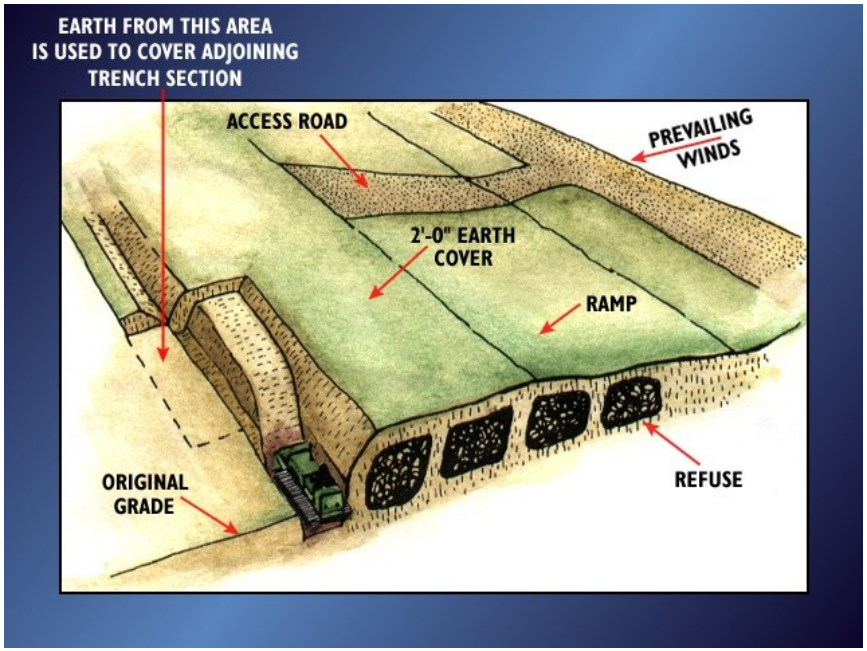
General Design Considerations	Need to burn at proper temperatures, develop strategy for handling waste ash, fuel requirements, waste volume, liquids content of waste, waste composition. Redundancy (i.e., back-up solution because it is still necessary to dispose of waste if an incinerator experiences periods of inoperability), space to operate, scalability of system
Limitations	Requires skilled personnel to build, operate and maintain. Cannot burn covered wastes (e.g., plastics, hazardous waste, medical waste, tires, treated wood)
Recordkeeping, Reporting	Location, contents of waste, dates of opening/closure, pictures, amount, air sampling
Capital Costs	Incinerator and supporting facilities and equipment
O&M Requirements	Skilled manpower to operate and maintain, removal and disposal of waste ash, fuel costs
Transfer/Closure Requirements	Bury any remaining ash. Decide whether to remove incinerator or leave in place and associated follow on actions. Place a rectangular sign on top of the site indicating the incinerator operations, the date it was closed, and the unit designation if the situation allows. An 8-digit grid coordinate is recorded for each waste burial site and reported to higher headquarters.
References	• U.S. Army Engineer School and Regiment, *Commander's Handbook: Waste Management for Deployed Forces*, April 2010 • U.S. Air Force Instruction, *Waste Management*, AFI 32-7042, 2010 • U.S. Army, *Environmental Considerations*, FM 3-34.5/MCRP 4-11B, Feb. 2010 • U.S. Air Force, *Environmental Considerations for Overseas Contingency Operations*, Air Force Handbook 10-222, Vol. 4

Engineered Landfill

- Advantages
  - Can handle all non-hazardous waste types
  - Low air emissions
- Disadvantages
  - High capital cost
  - Labor intensive
  - Largest space requirement
- Limitations
  - Not viable for small forces, short duration
  - Not viable in hostile environment
  - Siting distance from personnel and airfields

Duration Suitability Index

Short	Medium	Long



Engineered Landfill

General Design Considerations	Must have an impermeable liner to prevent groundwater and soil contamination. Must have leachate and gas collection systems. Must not be sited within 3,050m of airfields to prevent the threat of bird strikes. A 4:1 ratio of waste to cover material is required. Daily cover is required to reduce risk from vectors and pests.
Limitations	Force Protection, land availability and exclusion zones, base population, health concerns (vector-borne diseases)
Recordkeeping, Reporting	Location, contents of waste, dates of opening/closure, pictures, amount, soil sampling, groundwater sampling
Capital Costs	Impermeable liner, leachate and gas collection systems
O&M Requirements	Manpower to compact solid waste, provide daily cover and construct cells
Transfer/Closure Requirements	Three basic goals need to be achieved: 1) minimize the need for further maintenance at the site, 2) place the landfill in a condition that will minimize future environmental impacts, and 3) prepare the site for future use.
References	• U.S. Army Engineer School and Regiment, *Commander's Handbook: Waste Management for Deployed Forces*, April 2010 • U.S. Air Force Instruction, *Waste Management*, AFI 32-7042, 2010 • U.S. Army, *Environmental Considerations*, FM 3-34.5/MCRP 4-11B, Feb. 2010 • U.S. Air Force, *Environmental Considerations for Overseas Contingency Operations*, Air Force Handbook 10-222, Vol. 4 •U.S. Army, *Sanitary Landfill*, Technical Manual (TM) 5-814-5, January 1994 • U.S. Corps of Engineers, Department of the Army, *Engineering and Design: Sanitary Landfill Mobilization Construction*, Engineering Manual (EM) 1110-3-177, April 1984

Composting

- Advantages
  - Useable end product
  - Reduces disposal requirements
- Disadvantages
  - Capital cost
  - Requires knowledgeable personnel
- Limitations
  - Only for biodegradable portion (food waste)
  - Temperature limitations

Duration Suitability Index

Short	Medium	Long

Composting

General Design Considerations	Ensure a proper ratio of materials (Carbon:Nitrogen), wet and turn when required.
Limitations	Land availability, time requirement, cannot handle all wastes, temperature dependence
Recordkeeping, Reporting	Location, dates of opening/closure
Capital Costs	Composting containers and associated equipment
O&M Requirements	Manpower needed to monitor operations, wet and turn as needed
Transfer/Closure Requirements	If containers are used, determine whether to remove or leave in place
References	•U.S. Army Engineer School and Regiment, *Commander's Handbook: Waste Management for Deployed Forces*, April 2010 • U.S. Army, *Environmental Considerations*, FM 3-34.5/MCRP 4-11B, Feb. 2010 •U.S. Air Force, *Environmental Considerations for Overseas Contingency Operations*, Air Force Handbook 10-222, Vol. 4 • U.S. Corps of Engineers, Department of the Army, *Composting for Army Installations*, Public Works Technical Bulletin (PWTB) 420-49-14, 15 August 2000

Host Nation Collection

- Advantages
  - No land requirement
  - No capital investment
- Disadvantages
  - Force protection
  - Lead time for contract procurement
- Limitations
  - Limited by host nation’s capability
  - Quality assurance inspection required
  - Not suitable for sensitive material

Duration Suitability Index

Short	Medium	Long

Host Nation Collection

General Design Considerations	To protect base populace, locate solid waste transfer stations in a secure area with a route that does not pass by inhabited areas. Ideally, place the transfer station near or outside the base perimeter.
Limitations	Force Protection; lack of direct management oversight
Recordkeeping, Reporting	Copy of performance work statement and contract to provide proper quality assurance; contracting monitoring records
Capital Costs	Construction of a solid waste transfer station, waste transportation vehicles
O&M Requirements	Contract management
Transfer/Closure Requirements	Close contract and ensure contractor has fulfilled all requirements and received all required payments; sanitize and close transfer station; sanitize and prepare vehicles for final disposition
References	•U.S. Army Engineer School and Regiment, *Commander's Handbook: Waste Management for Deployed Forces*, April 2010 • U.S. Army, *Environmental Considerations*, FM 3-34.5/MCRP 4-11B, Feb. 2010 •U.S. Air Force, *Environmental Considerations for Overseas Contingency Operations*, Air Force Handbook 10-222, Vol. 4

Medical/Healthcare Waste Incineration

- Advantages
  - Effective
  - Small land requirement
  - Lower air emissions
- Disadvantages
  - Energy intensive
  - Requires skilled operator
- Limitations
  - Acquisition and delivery timeline

Duration Suitability Index

Short	Medium	Long

Medical Waste Incineration

General Design Considerations	Need to burn at proper temperatures, develop strategy for handling waste ash, fuel requirements, waste volume, liquids content of waste, waste composition Redundancy (need to dispose of waste should an incinerator experience periods of inoperability), space to operate, scalability of system. Remaining ash needs to be tested to determine if it is hazardous and must be disposed of properly.
Limitations	Requires skilled personnel to build, operate and maintain.
Recordkeeping, Reporting	Location, contents of waste, dates of opening/closure, pictures, amount, air sampling
Capital Costs	Incinerator
O&M Requirements	Skilled manpower to operate and maintain, removal and disposal of waste ash, fuel costs
Transfer/Closure Requirements	Decide whether to remove incinerator or leave in place. Dispose of any remaining ash Place a rectangular sign on top of the site indicating the incinerator operations, the date it was closed, and the unit designation if the situation allows. An 8-digit grid coordinate is recorded for each waste burial site and reported to higher headquarters.
References	• U.S. Army Engineer School and Regiment, *Commander's Handbook: Waste Management for Deployed Forces*, April 2010 • U.S. Air Force Instruction, *Waste Management*, AFI 32-7042, 2010 • U.S. Army, *Environmental Considerations*, FM 3-34.5/MCRP 4-11B, Feb. 2010 • U.S. Air Force, *Environmental Considerations for Overseas Contingency Operations*, Air Force Handbook 10-222, Vol. 4

Conclusion

- Early SW management planning has many benefits. It:
  - Enhances mission accomplishment by improving base camp quality of life
  - Contributes to force protection
  - Minimizes exposure to waste-related health issues
  - Promotes good relations with the Host Nation
  - Frees up resources for the mission (camp space, transportation, funds, etc.)
  - Minimizes unnecessary environmental damage
- Using a waste hierarchy helps to choose the best technology to minimize waste generation and save resources (manpower, funding and equipment)
- Proper SW management minimizes closure requirements